

## CLAIMS

Therefore, at least the following is claimed:

1. A digital subscriber line (DSL) transceiver, comprising:
  2. a pulse amplitude modulation (PAM) transmitter;
  3. a fractional encoder associated with the PAM transmitter, the fractional encoder configured to encode a non-integer number of bits for each word to be transmitted by the PAM transmitter; and
    6. a constellation encoder configured to encode each word containing the non-integer number of bits into a signal space constellation to be transmitted by the PAM transmitter, and where each signal space constellation comprises a symbol.
1. 2. The transceiver of claim 1, wherein the signal space constellation is generated by the PAM transmitter.
1. 3. The transceiver of claim 1, wherein the fractional encoder further comprises a modulus converter.
1. 4. The transceiver of claim 1, wherein the fractional encoder further comprises a shell mapper.
1. 5. The transceiver of claim 1, wherein the fractional encoder further comprises a constellation switcher.

1           6.       The transceiver of claim 1, wherein each symbol is transmitted using a  
2       single dimensional signal space constellation.

1           7.       The transceiver of claim 1, wherein each symbol is transmitted using a  
2       multi-dimensional signal space constellation.

1           8.       The transceiver of claim 1, further comprising a trellis encoder associated  
2       with the constellation encoder.

1           9.       The transceiver of claim 1, wherein the fractional encoder is configured  
2       to collect an integer number of bits  $S*K$ , over a frame comprising several symbol  
3       periods  $S$ , and is configured to encode the frame of  $S*K$  bits for transmission at a  
4       fractional bit rate of  $K$  bits per symbol.

1           10.      The transceiver of claim 9, wherein the fractional encoder is configured  
2       to convert the  $S*K$  bits of the frame into  $S$  integers, each of arithmetic base  $M$ , where  $M$   
3       corresponds to a plurality of PAM signal levels.

1           11.      The transceiver of claim 1, further comprising a fractional decoder  
2       configured to decode a received symbol into a non-integer number of bits.

1           12.      The transceiver of claim 11, wherein the fractional decoder is a modulus  
2       converter.

1           13. A method for encoding fractional bit rates using pulse amplitude  
2 modulation (PAM), the method comprising the steps of:  
3           providing a PAM modulator;  
4           using the PAM modulator to generate a transmit signal; and  
5           encoding the transmit signal with a modulation symbol representing a non-  
6 integer number of bits, wherein the sum of the bits over a plurality of symbol times  
7 results in an integer number of bits.

1           14. The method of claim 13, wherein the encoding step includes modulus  
2 conversion.

1           15. The method of claim 13, wherein the encoding step includes shell  
2 mapping.

1           16. The method of claim 13, wherein the encoding step includes constellation  
2 switching.

1           17. The method of claim 13, wherein the modulation symbol is encoded into  
2 a multi-dimensional signal space constellation.

1           18. The method of claim 13, wherein the modulation symbol is encoded into  
2 a single dimensional signal space constellation.

1           19. The method of claim 13, further comprising the step of trellis encoding  
2 the modulation symbol.

1        20.     The method of claim 13, further comprising the steps of:  
2            collecting an integer number of bits  $S*K$ , over a frame comprising several  
3        symbol periods  $S$ ; and  
4            encoding the frame of  $S*K$  bits for transmission at a fractional bit rate of  $K$  bits  
5        per symbol.

1        21.     The method of claim 20, further comprising the step of converting the  
2         $S*K$  bits of the frame into  $S$  integers, each of arithmetic base  $M$ , where  $M$  corresponds  
3        to a plurality of PAM signal levels.

1        22.     A digital subscriber line (DSL) transceiver, comprising:  
2            means for providing a PAM modulator;  
3            means for using the PAM modulator to generate a transmit signal, the transmit  
4        signal including a plurality of transmit symbols; and  
5            means for encoding each of the transmit symbols with a non-integer number of  
6        bits, wherein the sum of the bits over a plurality of transmit symbols results in an integer  
7        number of bits.

1        23.     The transceiver of claim 22, wherein the encoding means includes  
2        modulus conversion means.

1        24.     The transceiver of claim 22, wherein the encoding means includes shell  
2        mapping means.

1           25. The transceiver of claim 22, wherein the encoding means includes  
2 constellation switching means.

1           26. The transceiver of claim 22, wherein the transmit symbol is encoded into  
2 a single dimensional signal space constellation.

1           27. The transceiver of claim 22, wherein the transmit symbol is encoded into  
2 a multi-dimensional signal space constellation.

1           28. The transceiver of claim 22, further comprising means for trellis encoding  
2 each of the transmit symbols.

1           29. The transceiver of claim 22, further comprising:  
2           means for collecting an integer number of bits  $S*K$ , over a frame comprising  
3 several symbol periods  $S$ ; and  
4           means for encoding the frame of  $S*K$  bits for transmission at a fractional bit rate  
5 of  $K$  bits per symbol.

1           30. The transceiver of claim 29, further comprising:  
2           means for converting the  $S*K$  bits of the frame into  $S$  integers, each of  
3 arithmetic base  $M$ , where  $M$  corresponds to a plurality of PAM signal levels.